HYDRO-ELECTRIC INQUIRY COMMISSION

ENGINEERING DATA

THE ONTARIO POWER COMPANY OF NIAGARA FALLS

REPORT

ON

CONDITION OF CONDUIT NO. 1

AUGUST, 1922

WALTER J. FRANCIS, C. E.

CONSULTING ENGINEER

The Ontario Power Company of Niagara Falls.

REPORT ON CONDITION OF CONDUIT NO. 1

SEPTEMBER, 1922.

Walter J. Francis.

The Pacific Power Company of Niagara Falls.

MEMO ON CONNECTION OF CONDUIT NO. 1

NIAGARA, 1902.

Walter J. Francis.

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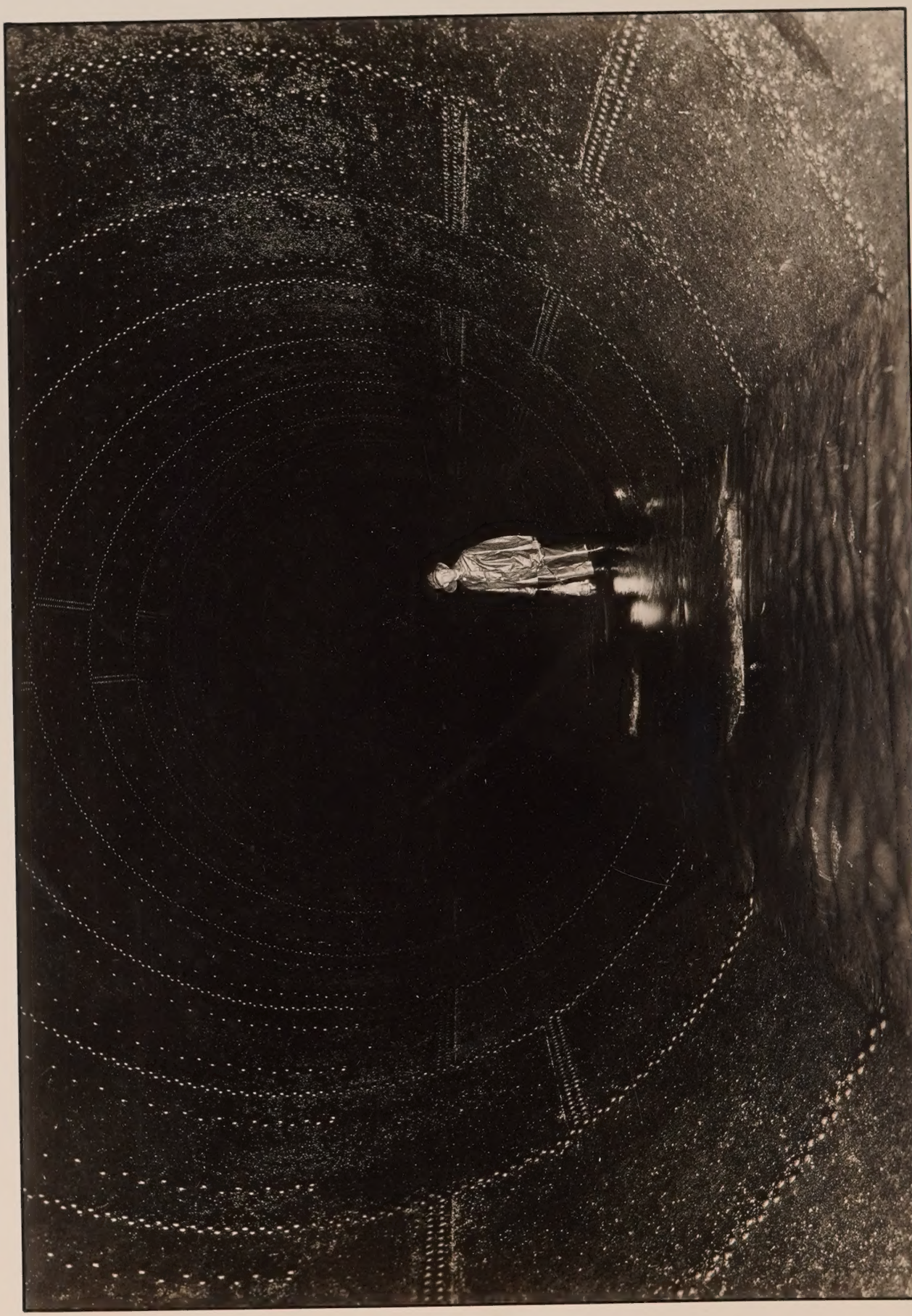

Interior of Conduit No. 1.

General Conditions at Time of Inspection

on August 6th, 1922.

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The Examination of the Interior.

On August 6th, 1922, the steel plate conduit, known as Conduit No. 1, of The Ontario Power Company of Niagara Falls, at Niagara Falls, Ontario, having been emptied of water, in company with Mr. H. G. Acres, Chief Hydraulic Engineer of the Hydro-Electric Power Commission, and Mr. Thos. H. Hogg and Mr. J. R. Montague of his staff, I made a careful inspection of its interior. Mr. H. C. Don Carlos, Chief Operating Engineer of the Hydro-Electric Power Commission, with Mr. G. O. Philp, Superintendent of The Ontario Power Company, and several members of his staff, were also examining the conduit at the same time.

We walked through the entire length of the conduit, from the headgate to the penstocks, and every member of the party carried an artificial light. With the exception of a narrow part of the invert of the conduit, over which a shallow stream of water was running as a result of a minor leakage in the seals of the headgate, the whole of the interior surface of the conduit was visible. The general view of the conduit, bound herewith as a frontispiece, shows the conditions quite clearly. Having noted such matters of interest as developed during our

journey to the end of the pipe, we embraced the opportunity of discussing them and making further examinations on the return journey to the headgate.

The conduit was refilled and put into service on August 8th, 1922.

The Location and the General Design of the Conduits of the Plant.

The water diverted from the Niagara River for the use of The Ontario Power Company of Niagara Falls is conducted from the intake and forebay at the edge of the river through three underground conduits to the penstocks leading to the turbines in the power house located in the gorge below the Falls. The water is admitted to the conduits through headgates, one headgate for each conduit. The distance from the headgates to the penstocks is 6,500 feet. The conduits have a total drop of 28 feet from the headgates to the penstocks, with a grade which is almost uniform. The alignment of the conduits is by curves of long radius, through a total deflection of nearly ninety degrees to the right as one travels from the headgates to the penstocks.

The first conduit which was installed is made of steel plate, and is designated Conduit No. 1. It is the most westerly of the three, the general line of the conduits being in a northerly direction. This conduit is of circular section with an internal diameter of 18 feet. The second conduit which was built is constructed of reinforced concrete, and is on the river side of Conduit No. 1. It is known as Conduit No. 2. The section of Conduit No. 2 is that described technically as a "hydrostatic chord", and has an area equivalent to that of a circle 18 feet in diameter. The third conduit, known as Conduit No. 3, was com-

pleted in 1919, on the river side of Conduit No. 2, that is nearest to the Niagara River. It is a wood-stave conduit of circular section measuring 13 feet 6 inches in internal diameter.

The Design and the Construction of Conduit No. 1.

Conduit No. 1 was built during the years 1903 and 1904 as part of the original installation of The Ontario Power Company of Niagara Falls. The engineers of the development were Messrs. P. N. and L. L. Nunn, and Mr. C. H. Mitchell (now General Mitchell) was Assistant Chief Engineer. Mr. Thos. H. Hogg was resident engineer on the construction work.

The plates used in the manufacture of the pipe are of steel, 1/2" in thickness, rolled in Scotland. The fabrication and erection was done under contract by Messrs. Jenckes Machine Co., of Sherbrooke, Quebec. All plates are 98-1/2" wide, the length being such that three similar plates make up the circumference of the pipe. The longitudinal joints are accordingly 8' 0" centre to centre. All joints are lapped 2-1/2", rivetted with 7/8" rivets, and caulked on the inside. All rivets have full round heads, and are not countersunk. The circumferential joints are arranged so that the sections telescope with all the caulking edges downstream. The longitudinal joints are located at the centre line at the top, and at a distance of one-sixth of the circumference from the bottom centre line, being staggered therefrom about sixteen inches from section to section in all cases to simplify rivetting. Stiffness was provided for the upper part of the steel shell of the conduit by rivetting stiffeners thereto on the outside at four

feet centre to centre, spaced so that the rivetted circumferential joint comes midway between two adjacent stiffeners. The stiffeners are composed of a single 7" bulb-tee weighing 25 pounds per lineal foot, continuous over the top of the shell and ending two feet below the axis of the shell on either side. The base of the tee is rivetted to the shell with 7/8" rivets at about 6 inches centre to centre.

The steel shell rested in a trench, part of which was in rock excavation and the remainder in earth. The specifications required careful back-filling and tamping. Throughout its length the steel shell was surrounded on the exterior with concrete 12 inches thick in order to preserve it and to increase its stability.

Conduit No. 1 was put into service on August 27th, 1905. It was unwatered in 1908 for the purpose of making repairs to certain valves, and again in 1914 for a brief inspection. There are no written records available concerning the condition of the conduit on either of these occasions.

General Mitchell and Mr. Hogg have informed me that the interior of the conduit received three coats of asphaltum paint applied strictly in accordance with the rules of the art, and that all the coats had ample time to dry and harden before the conduit was put into service.

The conduit was unwatered on August 5th, 1922, by closing its headgate and opening the penstocks leading from it, care being taken to drain it slowly so as to avoid strains due to accumulated pressure on the exterior. The unwatering was

completed in the space of about two hours.

The Condition of the Interior.

We entered Conduit No. 1 at eleven o'clock in the morning of August 6, 1922. I remained in it fully occupied with the inspection until nearly two o'clock in the afternoon, when I came out to amplify the notes I had made while within. Mr. Acres, Mr. Hogg and Mr. Montague remained within nearly two hours longer, and on emerging they confirmed the notes I had written.

The temperature in the conduit was about 70° Fahrenheit, and the humidity was very marked. The ventilation was good, there being an opening to the outside air at both ends of the conduit.

We had flashlight photographs taken as a record. The picture included as a frontispiece shows the general condition clearly.

Throughout the interior surface we could not find any trace of paint recognizable as such.

The surface of the steel plates and the rivet heads were free from heavy slime. Indeed, there was little or no trace of a slippery condition. About ten per centum of the area of the steel was as smooth as when it left the rolls, a great deal of this smooth surface giving one the distinct impression of the blue mill surface of the original plates. The balance of the surface was covered with a deposit, part of which seemed like a light coat of rust and the remainder like a calcareous incrustation of irregular shape about one sixteenth of an inch in

thickness, and in some cases more. Upon removing this deposit from the surface with a knife blade, no trace of pitting of the steel was found, but there is a general oxidation one one-hundredth of one inch or possibly one sixty-fourth of one inch in depth. This applies to the rivet heads as well as to the plate. On the whole the surface is in excellent condition.

In studying the incrustation, we observed many small worms crawling over the surface of the pipe, so numerous in places that half a dozen or more could be found within an area of one square inch. They were of whitish color, about three-quarters of an inch in length, having somewhat the appearance, one might say, of emaciated garden snails. Subsequently we examined the racks at the intake of the Toronto Power Company, a short distance downstream from the intake of The Ontario Power Company, and there on the steel bars below the water surface we found similar worms living in small calcareous houses apparently constructed out of a web secreted by the worm itself. These worms on the racks were dark in color, but we attribute this difference in appearance to the theory that those in Conduit No. 1 were either dying through being exposed to the air, or had become light in color owing to absence of sunlight. We endeavoured to ascertain the entomological classification of these creatures, and we believe them to be caddis worms. For present purposes, however, beyond recording the fact of their presence, it does not appear that any useful purpose will be served in following the subject, as there is nothing to indicate that these organisms will injuriously affect the steel of the conduit, although a slight degree of retardation of flow must naturally result.

The photograph included herewith as page 8 shows in clear detail the condition of the surface of the interior of the pipe. A portion of the surface of the steel between the rule and the chisel, as well as a rivet head three inches above the bottom of the rule and two others near the bottom of the chisel, we scraped and rubbed carefully. The balance of the surface within the field of the picture is as we found it. Along the caulking edge of the plates may be seen some of the calcareous incrustations. Certain of the large formations in the picture are also incrustations. The mill surfaces of the steel plate may be readily identified in the lighter colored, even-looking areas. The high lights in the picture, as for example the tops of the rivet heads, result from the use of the flash-light, and are not to be interpreted as polished surfaces.

In several places we noted irregular deposits of yellow color, half an inch or more in thickness, the patches being thickest in the centre and tapering off to nothing at the border. We removed several of these patches, and found no trace of pitting beneath them. Subsequent analyses in the laboratories of the Hydro-Electric Power Commission show the samples to be largely lime, silica, iron oxide and organic matter with traces of sulphur and magnesium. I am of the opinion that these patches have no significance.

The alignment of the conduit is for the most part perfect, and there is no evidence of any recent movement or distortion. I am of the opinion that the steel shell is in the same condition as regards alignment as it was when completed, and that there has been no effect thereon as a result of its filling, its long use or

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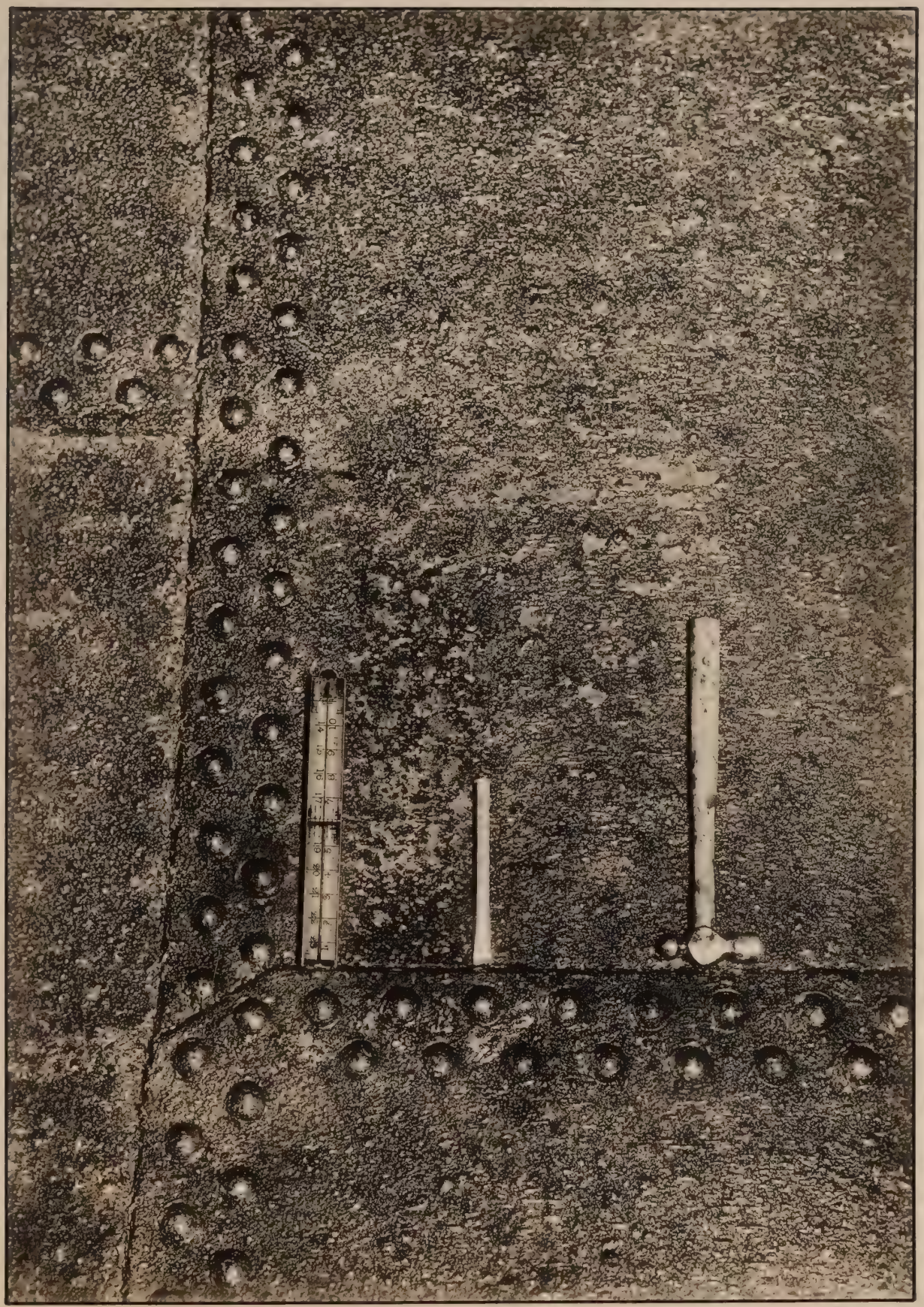
Interior of Conduit No. 1.

Detail of the Surface

August 6th, 1922.

Photograph taken by flash-light.



its emptying. In two places where the unevenness occurs in the invert, as confirmed by reference to the construction engineers, there is a small crack, but there is no evidence of recent origin, and I am disposed to believe they were there unnoticed when the pipe was completed. As they do not refer directly to the subject matter of this report, I have not pursued the study of them. In any event they do not impair the service of the conduit in any way.

Examinations and Condition of the Exterior.

On September 16th, 1922, I made an examination of the exterior of the conduit in company with Mr. Philp, at the manhole near the entrance to the elevators and about a hundred yards southerly therefrom. Mr. Mountford, Mechanical Supervisor of The Ontario Power Co. was also present. During construction an inspection manhole had been made leading down to a drainage system, in which about one-third of the circumference of the steel shell for a length of three feet has been left exposed ever since. The conditions here are as severe as one can conceive in work of this nature. The steel is found to be deteriorated to a depth of one thirty-second of one inch and in some places to probably one sixteenth of one inch. This depth of deterioration was subsequently confirmed by drilling a small hole through the steel plate. Little trace of the original asphaltum paint remains.

Mr. Philp has made an excavation through the earth and the concrete envelope to determine the condition of the steel shell at a point about 100 feet south of the power house of the Canadian Niagara Power Co. He found about 6

feet of earth cover, with good concrete 12 inches thick on top of the steel. He reports that there is not the least trace of rust on the steel, and that the paint on the exposed stiffener tee is in good condition. This examination was made on September 25th, 1922.

Conclusions.

From the examinations referred to, which show the condition of the conduit after seventeen years of continuous service, I am of the opinion that the remaining useful life of the conduit itself is probably fifty years. In the interior the conditions in August last, after the long period of service, were almost exactly what I should have expected to find after six months of service.

In general, I believe the conclusion may be safely drawn that the waters of the Niagara River have no unduly detrimental effect, physically or chemically, on steel conduits used in the manner in which Conduit No. 1 has been used, and, consequently, that steel may be safely used there with the confidence that its useful life will be very long and comparable in a great measure with the life of other construction materials ordinarily considered as permanent.

Walter J. Francis
Consulting Engineer.

Toronto, September 26th, 1922.